



### Robots Go Where Scientists Fear to Tread

ATLANTA - Scientists are diligently working to understand how and why the world's ice shelves are melting. While most of the data they need (temperatures, wind speed, humidity, radiation) can be obtained by satellite, it isn't as accurate as good old-fashioned, on-site measurement and static ground-based weather stations don't allow scientists to collect info from as many locations as they'd like.

Unfortunately, the locations in question are volatile ice sheets, possibly cracking, shifting and filling with water — not exactly a safe environment for scientists.

To help scientists collect the more detailed data they need without risking scientists' safety, researchers at the Georgia Institute of Technology, working with Pennsylvania State University, have created specially designed robots called SnoMotes to traverse these potentially dangerous ice environments. The SnoMotes work as a team, autonomously collaborating among themselves to cover all the necessary ground to gather assigned scientific measurements. Data gathered by the SnoMotes could give scientists a better understanding of the important dynamics that influence the stability of ice sheets.

"In order to say with certainty how climate change affects the world's ice, scientists need accurate data points to validate their climate models," said Ayanna Howard, lead on the project and an associate professor in the School of Electrical and Computer Engineering at Georgia Tech. "Our goal was to create rovers that could gather more accurate data to help scientists create better climate models. It's definitely science-driven robotics."

Howard unveiled the SnoMotes at the IEEE International Conference on Robotics and Automation (ICRA) in Pasadena on May 23. The SnoMotes will also be part of an exhibit at the Chicago Museum of Science and Industry in June. The research was funded by a grant from NASA's Advanced Information Systems Technology (AIST) Program.

Howard, who previously worked with rovers at NASA's Jet Propulsion Laboratory, is working with Magnus Egerstedt, an associate professor in the School of Electrical and Computer Engi-

neering, and Derrick Lampkin, an assistant professor in the Department of Geography at Penn State who studies ice sheets and how changes in climate contribute to changes in these large ice masses. Lampkin currently takes ice sheet measurements with satellite data and ground-based weather stations, but would prefer to use the more accurate data possible with the simultaneous ground measurements that efficient rovers can provide.

"The changing mass of Greenland and Antarctica represents the largest unknown in predictions of global sea-level rise over the coming decades. Given the substantial impact these structures can have on future sea levels, improved monitoring of the ice sheet mass balance is of vital concern," Lampkin said.

"We're developing a scale-adaptable, autonomous, mobile climate monitoring network capable of capturing a range of vital meteorological measurements that will be employed to augment the existing network and capture multi-scale processes under-sampled by current, stationary systems."

The SnoMotes are autonomous robots and are not remote-controlled. They use cameras and sensors to navigate their environment. Though current prototype models don't include a full range of sensors, the robots will eventually be equipped with all the sensors and instruments needed to take measurements specified by the scientist.

While Howard's team works on versatile robots with the mobility and Artificial Intelligence (A.I.) skills to complete missions, Lampkin's team will be creating a sensor package for later versions of Howard's rovers.

Here's how the SnoMotes will work when they're ready for their glacial missions: The scientist will select a location for investigation and decide on a safe "base camp" from which to release the SnoMotes. The SnoMotes will then be programmed with their assigned coverage area and requested measurements. The researcher will monitor the SnoMotes' progress and even reassign locations and data collection remotely from the camp as necessary.



Above: Principal Investigator Ayanna Howard working on a SnoMote.

When Howard's research team first set out to build a rover designed to capture environmental data from the field, it took a few tries to come up with an effectively hearty design. The group's first rover was delicate and ineffective. But after an initial failure, they decided to move on to something designed for consistent abuse — a toy. Instead of building yet another expensive prototype, Howard instead opted to start with a sturdy kit snowmobile, already primed for snow conditions and designed for heavy use by a child.

Howard's group then installed a camera and all necessary computing and sensor equipment inside the 2-foot-long, 1-foot-wide snowmobile. The result was a sturdy but inexpensive rover.

By using existing kits and adding a few extras like sensors, circuits, A.I. and a camera, the team was able to create an expendable rover that wouldn't break a research team's bank if it were lost during an experiment, Howard said. Similar rovers under development at other universities are much more expensive, and the cost of sending several units to canvas an area would likely be cost-prohibitive for most researchers, she added.

The first phase of the project is focused primarily on testing the mobility and communications capabilities of the SnoMote rovers. Later versions of the rovers will include a more developed sensor package and larger rovers.

The team has created three working SnoMote models so far, but as many SnoMotes as necessary can work together on a mission, Howard said.

The SnoMote represents two key innovations in rovers: a new method of location and work allocation communication between robots and maneuvering in ice conditions.

Once placed on site, the robots place themselves at strategic locations to make sure all the assigned ground is covered. Howard and her team are testing two different methods that allow the robots to decide amongst themselves which positions they will take to get all the necessary measurements.

The first is an "auction" system that lets the robots "bid" on a desired location, based on their proximity to the location (as they move) and how well their instruments are working or whether they have the necessary instrument (one may have a damaged wind sensor or another may have low battery power).

The second method is more mathematical, fixing the robots to certain positions in a net of sorts that is then stretched to fit the targeted location. Magnus Egerstedt is working with Howard on this work allocation method.

In addition to location assignments, another key innovation of the SnoMote is its ability to find its way in snow conditions. While most rovers can use rocks or other landmarks to guide their movement, snow conditions present an added challenge by restricting topography and color (everything is white) from its guidance systems.

For snow conditions, one of Howard's students discovered that the lines formed by snow banks could serve as markers to help the SnoMote track distance traveled, speed and direction. The SnoMote could also navigate via GPS if snow bank visuals aren't available.

While the SnoMotes are expected to pass their first real field test in Alaska next month, a heartier, more cold-resistant version will be needed for the Antarctic and other well below zero climates, Howard said. These new rovers would include a heater to keep circuitry warm enough to function and sturdy plastic exterior that wouldn't become brittle in extreme cold.

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